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A new species of *Charinus* (Amblypygi: Charinidae) from Ghana, with notes on West African whip spiders

Danilo Harms[1]

[1] *Zoological Museum, Center of Natural History, University of Hamburg, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany*

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Corresponding author: *Danilo Harms* (danilo.harms@uni-hamburg.de)

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Abstract

The fauna of whip spiders (Amblypygi) in Western Africa is poorly known but probably diverse. Here, I describe the new species *Charinus kakum* **sp. n.** based on female morphology, and accompanied by DNA sequence data. The species is small and differs from other African species of *Charinus* in the low number of pseudosegments on leg IV, female genital features, spination patterns of the pedipalp, and small body size. It was collected from wet tropical rainforest in Kakum National Park, Ghana and is only the fourth species of *Charinus* to be recorded from the highly diverse Western African biodiversity hotspot. With a total body length of not even 6 mm it is also one of the smallest whip spiders in the world.

Introduction

The mesic forests of Western Africa are a biodiversity hotspot and notable for their iconic fauna which includes more than 320 mammals and almost 800 bird species (Mittermeier et al. 2004). This fauna is threatened by rapid habitat loss caused predominantly by logging, plantation agriculture and mining. The invertebrate fauna of Western Africa is still largely unexplored, even compared with other hotspots, and very little is still known about the arachnid fauna. This is particularly the case for whip spiders (Amblypygi), a small order of arachnids with more than 200 species that occur in tropical and subtropical regions all over the world (Harvey 2013; Miranda et al. 2016a). Whip spiders are easily recognized by their flattened body, the robust pedipalp with strong spines that function as a trapping basket for prey, and the first legs that are strongly elongated and have sensory function (Weygoldt 1996, 2000a; Garwood et al. 2017). All whip spiders are nocturnal hunters and usually found on bark, in caves or under rocks. The Western African fauna currently comprises eight species in the genera *Charinus* (3 species), *Damon* (4 species) and *Phrynichus* (1 species). As such, whip spiders are poorly known here by comparison with other regions in Africa, say Tanzania, where 10 species have been described (Harvey 2013). The primary reason for this low number is probably sampling effort and the scarcity of comprehensive invertebrate surveys in Western Africa, but also the lack of taxonomists studying the invertebrate fauna of this region.

Here, a new species of whip spider is described that was collected during recent fieldwork in Kakum National Park, Ghana. This species is small and belongs to the circumtropical genus *Charinus* which occurs in Western Africa with three described species: *Charinus fagei* Weygoldt, 1972 and *Charinus milloti* Fage, 1939 from caves in Guinea, and *Charinus africanus* Hansen, 1921 from Equatorial Guinea and the islands of São Tomé and Prínci-

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pe. All species of *Charinus* are small by comparison with *Damon* and *Phrynichus* (usually < 1.5 cm in body length) and collected infrequently because of their cryptic nature. *Charinus kakum* sp. n. is only the second species of whip spider to be described from Ghana, apart from the much larger *Damon medius* (Herbst, 1797) (Harvey 2013).

This paper aims to describe the first species of *Charinus* from Ghana based on female morphology, but also provides a DNA barcode that will help to delineate this species from others. In documenting this species, I hope to raise further awareness of the potentially diverse but clearly understudied arachnid fauna of Western Africa, which remains to be documented and studied on detail to assist conservation efforts.

Methods

Morphology. The holotype of *Charinus kakum* was stored in 100 % ethanol but transferred to 75 % ethanol for morphological examination. A fragment of leg IV was removed prior to the examination for molecular analyses. Imaging of key-taxonomic characters was achieved using a custom-built BK Plus Lab System by Dun, Inc with integrated Canon EOS camera, macrolenses (65 mm and 100 mm) and the stacking software Zerene Stacker. The images were edited and formatted in Adobe Photoshop CS6. Measurements were taken using a micrometric ruler fitted on the eyepiece of a Leica M125 stereomicroscope and are expressed in millimeters (mm). Abbreviations: Bt = Basitarsus; Dt = Distitarsus; Fe = Femur; Ti = Tibia; Tr = Trochanter; LE = lateral eyes; ME = median eyes. The terminology of body parts follows Weygoldt (2000a) and spine counts were made from proximal to distal.

Molecular study. A 632 bp fragment of the mitochondrial CO1 gene was amplified using the protocol described in a previous study (Harms and Framenau 2013), except that the Chelex protocol (Walsh et al. 1991) was used for DNA extraction.

Taxonomy

Charinidae Quintero, 1986

Charinus Simon, 1892

Type species. *Phrynus australianus* L. Koch, 1867, by original designation.

Taxonomic remarks. Weygoldt (2000a) defined *Charinus* based on the armature of the pedipalp: with three large dorsal spines on the tibia of which the first one is the largest and the others decrease proximally in length; spine 1 sometimes followed distally by one to three spinelets, pedipalp basitarsus with two spines of which the distal spine is largest. *Charinus* also differs from the closely related *Sarax* in lacking ventral sac covers (Rahmadi and Kojima 2010). The genus currently includes more than 70 species (Vasconcelos and Ferreira 2017) but is in need of revision (Weygoldt 2000a, b). Nonetheless, the new species aligns well with the current genus diagnosis and is placed here until such revision has been carried out.

Charinus kakum sp. n.

http://zoobank.org/FFC44C02-FB47-4B54-BE2B-25A07EEEFF95

(Figs 1–5)

Type material. Female holotype: GHANA, Central Province, Kakum National Park, Track to Treehouse (5°21'21.23"N; 1°22'55.87"W), under flat rock near forest floor, 13.XII. 2017, coll. D. Harms and B.K. Williams (ZMH-A0000893).

Diagnosis. *Charinus kakum* sp. n. differs from the cave-inhabiting species *C. milloti* Fage, 1939 and *C. fagei* Weygoldt, 1972 in low number of tibial segments on leg IV (5 in *C. millotei* and *C. fagei* vs. 3 in *C. kakum*), trichobothria patterns of leg IV (compare with Weygoldt 1972, 2000a), small body size (prosoma length 2.6 in *C. kakum*), and shorter legs; from the island species *C. africanus* Hansen 1921 through the female genital operculum which has a steep ventral flexure at about two third of its length in *C. africanus* (Weygoldt 1972; Miranda et al. 2016b) but is uniform in *C. kakum*, and body size (ca. 8.0–8.5 mm in *C. africanus* and 5.8 in *C. kakum*; Hansen 1921).

Description. *Carapace:* flattened and wider than long (Figs 3A, C), uniformly brown except for the margins that are pale. Ratio length/width approximately ¾. Anterior margin rounded and with six spines situated anterior to the ME, individual spines projecting upwards. ME well developed, projecting forwards and situated on a common dark tubercle. LE well developed and on a common tubercle, projecting sideward. Fovea well developed and rounded, followed by a triangular depression at the posterior margin of the carapace. Three additional depressions in lateral position: i) smallest situated posterior to the LE; ii) a second larger depression in mediolateral position; and iii) a posterior-lateral position. Carina runs from the corners of the anterior margin and extends from the coxae of legs I to the corners of the posterior margin. Small granules and punctuations present, denser at the anterior region and pars cephalica. *Sternum:* tri-segmented but individual segments weakly sclerotized and rounded (Fig. 3B, D), pale except for the reddish-brown sternites. Tritosternum projected anteriorly and reaching far into the coxae of the pedipalps, elongate and cone-shaped, with one apical pair of spines, one medial pair, and ca. 6 spinelets at the base, distal margins serrate, base more or less triangular. Tetrasternum (second segment) rounded and hard to discern, with a pair of spinelets. Pentasternum (third segment) reduced and hard to discern, with a pair of setae (or small spinelets). Two additional setae between coxae of leg IV. The segments separated from each other by ca. 1.5 times the diameter of the tetrasternum. *Opisthosoma:* ovate and light brown, except

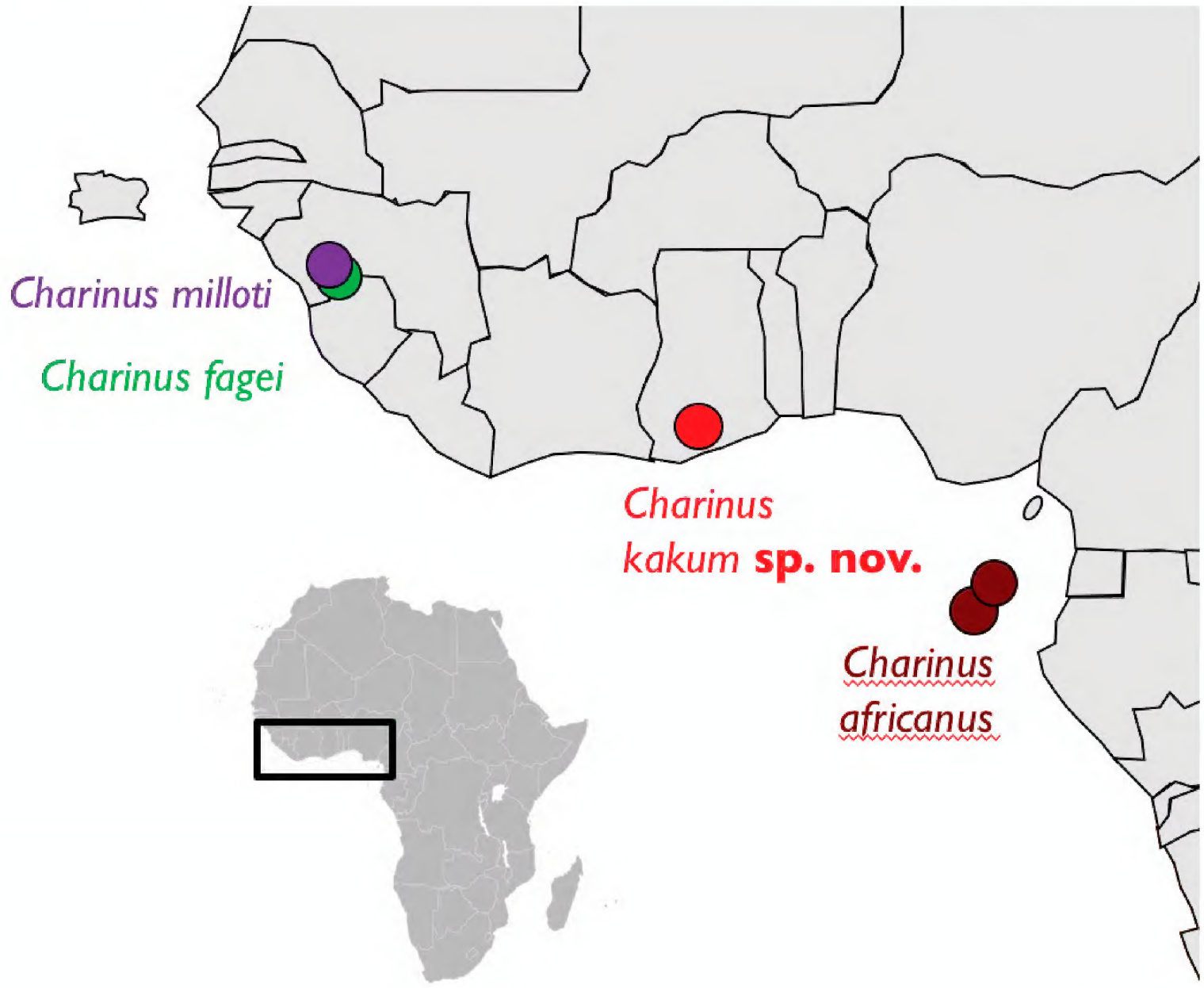

Figure 1. Distribution map showing the type localities of the described species of *Charinus* in West Africa according to Harvey (2013). The type locality of *Charinus kakum* sp. n. is highlighted in red. Note that the localities for *Charinus milloti* and *C. fagei* may contain some error because both species were originally described from caves with an unknown location. The symbols indicate the regions in which the caves may be located.

for the tergites that are brown (Figs 2 C; 3A, B). Tergites with punctuations, in particular the distal positions. Tergites distally also with a small longitudinal row of up to 6 tiny setae. *Chelicera:* Cheliceral furrow with 4 teeth of the basal segment (Figs. 4D, E; 5B). Proximal tooth largest, size range: IV>I>II>III. Distal tooth bifid and distal cusp larger than proximal cusp. Claw with 5 basal teeth, the 3 proximal teeth on a common base; some fine hairs at the retrolateral margin, condyle strongly sclerotized and reddish-brown, fang brown. Basal segment dorsally with four setae: first one situated distally near fang condyle, two medio-distal, and one in medial position. Both sides of basal segment with a longitudinal band of five or six fine setae. Ventral side of basal segment setose and reddish. *Pedipalp:* Trochanter (Fig. 4A–C): Ventral apophysis sharply pointed and with a series of 14 strong spines (Fig. 4C); distal three largest, proximally decreasing in size; prolateral side with one spine and 3 spinelets (Fig. 4A). Femur: with three rows of spines, prolateral row with 5 setiferous tubercles, median row with large 3 spines (size ranges distal to proximal II>III>I), and retrolateral row with 4 spines (size range distal to proximal II>III>I>IV). Spines of retrolateral row largest. Size distal to proximal II>III>I>IV. Some setae present distally in pro- and retrolateral position (Fig. 4A, B; 5A). Tibia: with typical charinid spine armature (Weygoldt 2000a). Retrolateral side with 3 spines and one distal setiferous tubercle; distal spine largest and and spines proximally decreasing in length (III>II>I), distal setiferous tubercle near base of basitarsus in front of largest spine; Prolateral side with 2 spines and one proximal spinelet, distal spine largest. Dorsal side of tibia adorned with setae that distally decrease in length. Basitarsus: broadly flattened and each side with 2 spines, distal ones largest but proximal spine in retrolateral position much smaller (Fig. 4A). Retrolateral surface with several spinelets, prolateral surface smooth and with a median row of three trichobothria-like setae plus three additional setae more retrolaterally. Distitarsus: with 2 small spines above the cleaning organ, distal one about twice the size of proximal spine. Dorsal side setose, ventral side with ca. 10 long setae which are distally serrate. Cleaning organ occupies about 1/2 of the article length. Claw: long and with sharp curved tip, ca. 2/3 the length of distitarsus, divided from distitarsus and not fused. *Legs:* All moderately setose. Femur lengths: I>III>II>IV. Leg I: tibia with 24 articles and tarsus with 41 articles. Leg IV: Barsitibia with 3 pseudoarticles and distitarsus undivided. Trichobothria pattern: pseudosegment one: 1, two: 1, three: 11 (Fig. 5D). All claws smooth and not serrate. All walking legs with pulvilli that are

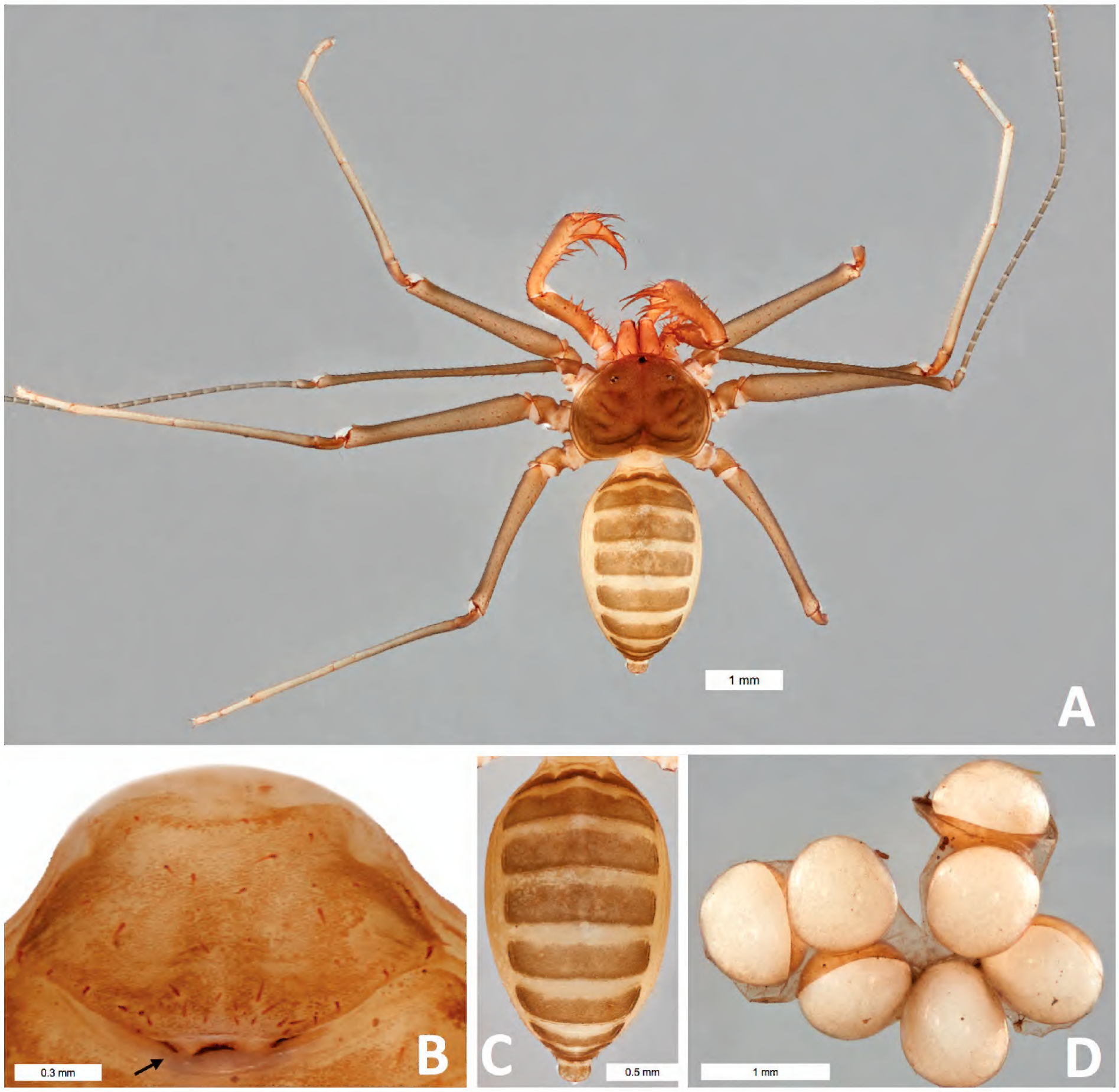

Figure 2. Female holotype of *Charinus kakum* sp. n.: **A**, habitus dorsal; **B**, genital operculum in ventral view. Arrow indicates the position of the ventral sac covers; **C**, opisthosoma in dorsal view; **D**, eggs carried by the female (removed from the genital operculum for imaging).

slightly smaller than the claws. *Genitalia:* Genital operculum rounded but distolateral margins concave (Fig. 2B). Sparsely setose in the proximal section but distal margins with ca. 22 setae. Genital opening rounded and slightly concave in distal view. Ventral sac covers visible and medially fused. Gonopods longer than wide and with rounded openings (Fig. 5C), separated by ca. the diameter of their base; otherwise indistinct and comparable to other species of the genus (e.g. compare Vasconcelos and Ferreira 2017).

Colour. Body chestnut brown (dark brown in the life animal), abdomen yellowish except for the tergites. Chelicerae and distal sections of the pedipalp reddish (Figs 2A; 3A, B).

Measurements. Total length 5.8: Carapace: Length: 2.6; Width: 1.9; Opisthosoma Length: 3.3; Opisthosoma Width: 2.25. Left Pedipalp: Femur: 1.35; Tibia: 1.66; Basitarsus: 0.57; Distitarsus: 0.58; Claw 0.43. Chelicera (basal segment): Length: 0.85. Width: 0.53.

Etymology. The specific epithet refers to the type locality, Kakum National Park in Ghana.

CO1 gene sequence. GenBank Submssion No. MH107031.

Distribution. Only known from the type locality by a single female individual. The wider distribution remains unknown and unfortunately no other specimens could be collected, despite targeted searches in the vicinity of the type locality.

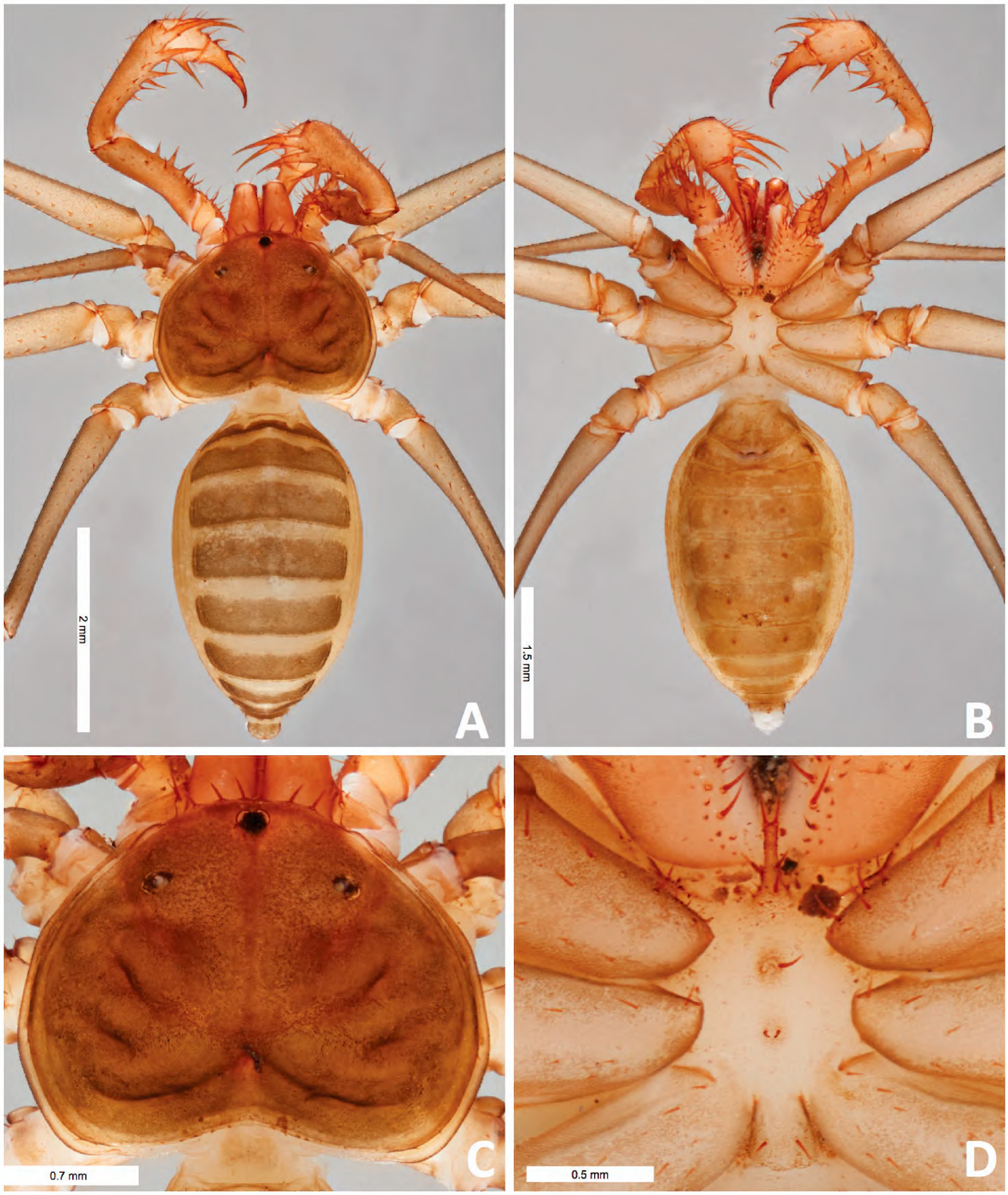

Figure 3. Female holotype of *Charinus kakum* sp. n.: **A**, details of habitus in dorsal view; **B**, details of habitus in ventral view; **C**, carapace in dorsal view; **D**, prosomal sternites in ventral view.

Habitat. The species was collected in closed primary rainforest in Kakum National Park, Ghana (Fig. 1). It was found in a small rocky outcrop close to a dry creek-bed under a rock which was positioned directly on top soil. Other arachnids that were seen at this outcrop included *Ricinoides* sp. (Ricinulei) and schizomids (Uropygi: Schizomida). No other specimens could be found under adjacent rocks or tree bark. Kakum National Park comprises moist evergreen (where the holotype was collected) and swamp or riverine forests. Average annual rainfall is ca. 1380 mm and the elevation range is 135–250 meters.

Notes on biology. The collected female was brooding and carried a total of seven eggs in a brood sac. These

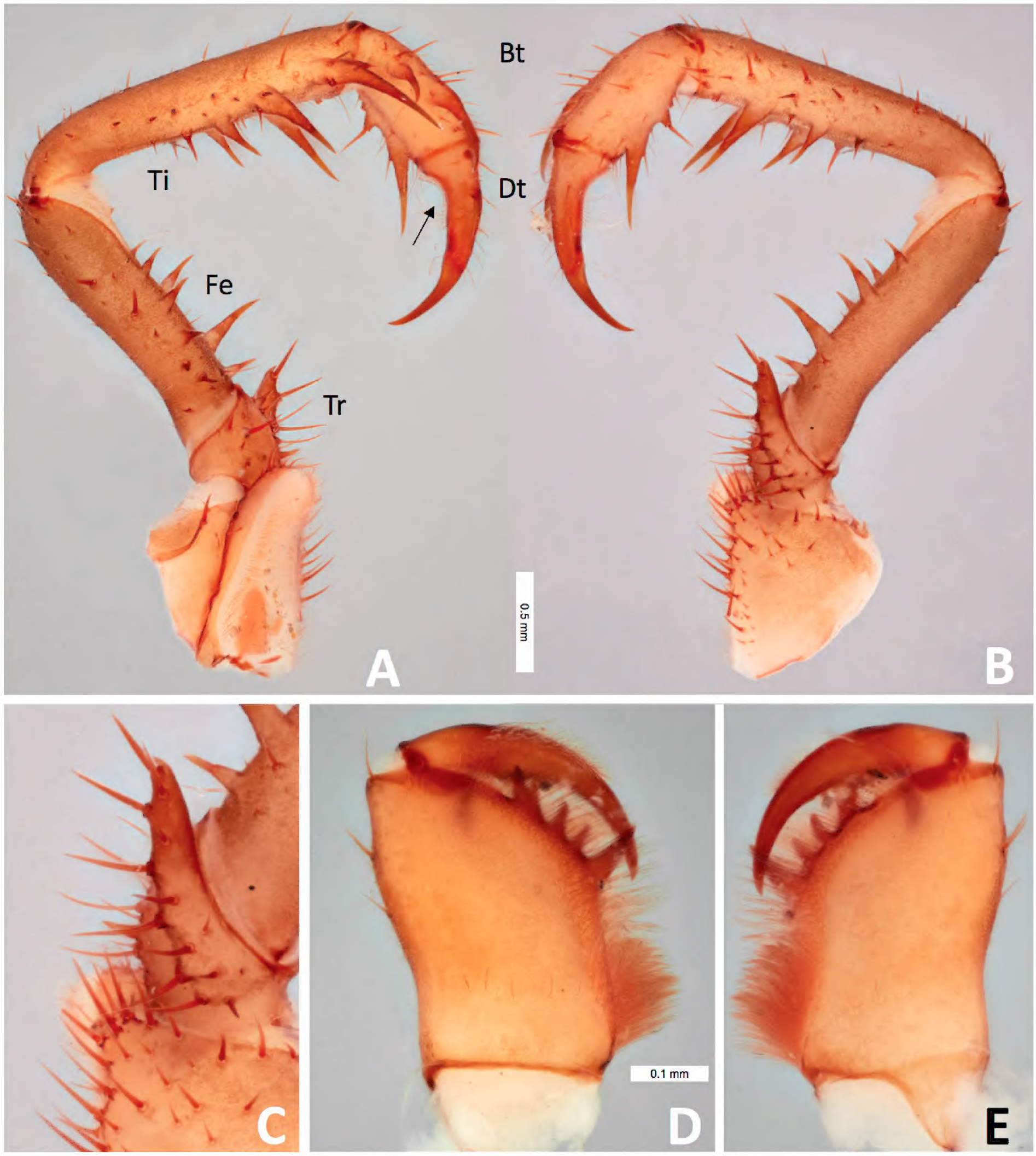

Figure 4. Female holotype of *Charinus kakum* sp. n.: **A**, left pedipalp in prolateral view. Arrow points to the position of the cleaning organ; **B**, left pedipalp in retrolateral view; **C**, ventral spiniform apophysis, retrolateral view; **D**, right chelicera in retrolateral view; **E**, same in prolateral view.

eggs were large, ca. 1.25 mm in diameter (Fig. 2D). Considering the low number of eggs and their large size, the reproductive potential of this species is considered to be low. Nothing else is known about the biology and distribution of this species. So far, it is the smallest whip spider in western Africa and may have a preference for rocky boulders in densely vegetated areas, under which it retreats.

Discussion

Whip spiders have rarely been recorded in Western Africa but this probably indicates the poor state of collecting compared to other regions of the continent, in particular eastern and southern Africa. The current knowledge on African whip spiders was summarized by Weygoldt (1998b; 1999, 2000a) who recognized seven species of

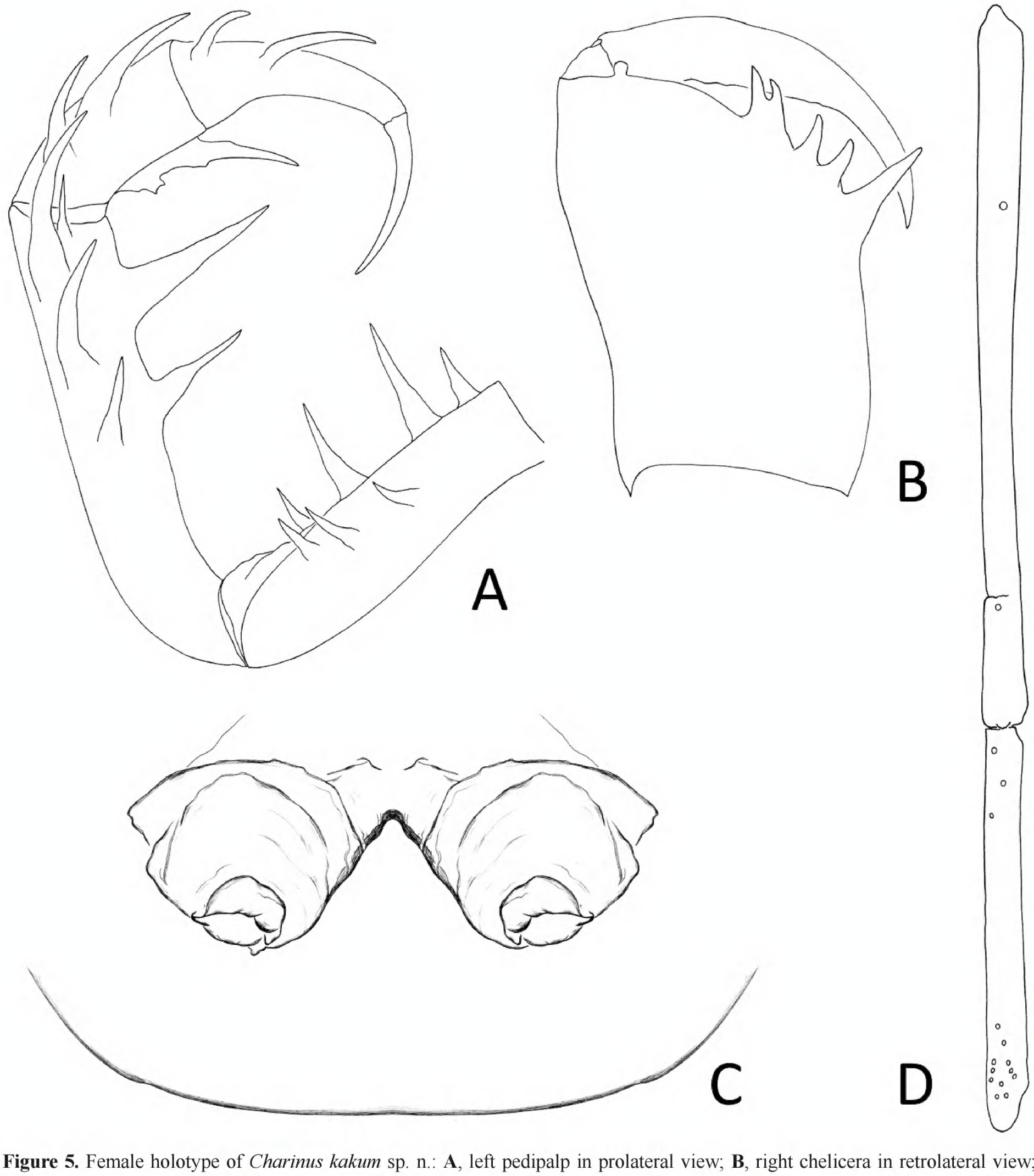

Figure 5. Female holotype of *Charinus kakum* sp. n.: **A**, left pedipalp in prolateral view; **B**, right chelicera in retrolateral view; **C**, female gonopods, dorsal view; and **D**, trichobothria patterns on leg IV.

Charinus in Africa: *C. abbatei* Delle Cave, 1986 from Somalia, *C. africanus* from islands in the Gulf of Guinea, *C. diblemma* Simon, 1936 from Zanzibar, *C. fagei* Weygoldt, 1972 and *C. milloti* Fage, 1939 from Guinea, *C. jeanneli* Simon, 1936 in Tanzania, and *C. madagascariensis* Fage, 1954 from Madagascar; but note that there is uncertainty about the status of *C. diblemma* and *C. jeanneli* which are currently considered *nomen dubia* (Harvey 2013).

Aside from the little-known small species of *Charinus*, more data are currently available on the large species belonging to *Damon* and *Phrynichus*, which are collected and studied more frequently at the systematic level (e.g. Weygoldt 1999b, Prendini et al. 2005) but also in terms of behavior and mating biology (e.g. Weygoldt 1998a, 1999a). Most of the large species are currently understood to be widespread and have linear ranges of 500 km

or more, as evidenced by morphological and molecular data (Weygoldt 2000b; Prendini et al. 2005). Very little is known about the diversity and distribution of the much smaller and cryptic species of *Charinus,* which are collected infrequently but are also less common in museum collections. No molecular phylogenetic or phylogeographic studies are currently available for this fauna, but it is notable that records of the described *Charinus* species are often from the locus typicus or smaller areas, such as a couple of islands in the case of *C. africanus* (Harvey 2013). Nothing is known about the dispersal capacities of these whip spiders but it could be that the ranges of some species are quite restricted and dispersal capacities are often low. This claim may be supported by the large number of cave-dwelling species that are endemic to a specific karst system. Conversely, other species, such as *Charinus ioanniticus* (Kritscher, 1959) from the eastern Mediterranean, have been collected from rocky crevices, caves and cellars in Greece Turkey, Israel and Egypt (Blick and Seiter 2016; Miranda et al. 2016b) and seem to be widespread, although the latter claim is based on an interpretation of morphological characters and needs to be retested using genetic data. Detailed molecular phylogeographic studies on single species and the genus as a whole are clearly needed to infer range sizes and distributions but this can only be achieved through field work and more comprehensive surveys, which in the case of Western Africa have yet to be undertaken. The lack of any reference sequences for *Charinus* from Africa on Genbank and BOLD also illustrates the poor state of knowledge at the molecular level and more data are also needed here.

It should also be noted that *Charinus* is probably polyphyletic and in urgent need of revision (Weygoldt 2000a, b). The type species of *Charinus* is from Samoa in the Pacific (*C. australianus* (L. Koch, 1867)) and it is quite possible that the African species will form a distinct genus following detailed analysis. Miranda et al. (2016b) recently defined species-groups within *Charinus* based on female genital morphology that show some geographical clustering (e.g. *bengalensis*-group for eight species from Africa, Arabia and central Asia) but again, molecular phylogenetic studies are needed to settle genus limits and distributions, and it is unclear whether this group is monophyletic. A PhD thesis on the systematics of Charinidae remains to be published (Miranda 2017) but this important work will hopefully clarify the status of the African species. Detailed re-illustration of the type material of the West African species *C. africanus* (probably Natural History Museum of Denmark), and *C. millotei* and *C. fagei* (Muséum national d'histoire naturelle Paris) may also help in this context.

Finally, this new species of *Charinus* is yet another example of how critically the Western African biota are undersampled for arachnids. Very little is still known about the invertebrate fauna of this biodiversity hotspot and many more species of Amblypygi will surely occur in Western Africa. Weygoldt (2000b) noted that "a close look in humid caves and in rain forests will reveal the existence of more species of the Charinidae in Africa. All species are small and hard to find". Indeed, a recent study of karst invertebrates has documented whip spiders in at least three caves in different regions (Philips et al. 2016) and given the amount of range restriction in cave invertebrates, it is possible that these represent additional species of *Charinus*. Considering also that the main threat to invertebrate diversity in Western Africa is habitat loss through logging and agriculture, time is running thin to document this diversity and generate baseline data for nature conservation.

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